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Moment Measures in Relation to the Depositional Environment of Sands, a Critique

By **Gerald M. Friedman**

(Rensselaer Polytechnic Institute, Troy, New York)

Gees (1965) attempted to use moment measures to distinguish between the depositional environments of sands as outlined by this writer (1961, 1962). He concluded that it was not possible to distinguish the environments by the use of moment measures. He stated (p. 213) that 'no immediate explanation for the discrepancies between G. M. Friedman's (1961) results and our own can be given'. The purpose of this discussion is to supply the explanation.

It has been shown (Friedman, 1962, p. 743) that the factors that determine the shape of the size frequency distributions include, among others, (1) the sampling procedure which is adopted, and (2) the analytical method. It took several years of study to narrow down the various factors which influence discrepancies in size frequency distribution between different sampling procedures and techniques. It was pointed out (Friedman, 1961, p. 515) that to obtain consistently meaningful results in the field the samples had to be taken parallel to the bedding to avoid mixing of populations. Each bedding plane, sometimes a fraction of a centimeter in thickness, reflects a given energy level. Sampling across these bedding planes, which in the field are often difficult to see and appreciate, gives meaningless averages which do not reflect depositional environment. Commonly it is difficult to get more than several hundred grams of sample because of the extreme care necessary. Gees (p. 210) took two pounds of sand at each sampling point for his river sands with, as he puts it, 'no special precaution'.

One of the most important factors that influence moment measures is the shape of the tail of the distribution curve. This tail consists of the very fine grained sand, silt and clay fractions. In fact this tail is so important that in more recent studies (Friedman, 1965a, b, c) the analytical values obtained for the fine grained fraction have been accentuated by assigning to them arbitrary values of 6Φ. The absence of silt and clay at the fine grained end of the distribution curve means an energy level that removed these fine grained particles or never allowed them to be deposited. Gees in his analytical approach washed the samples through a U.S.B.S. No. 230 sieve and thereby removed the fine grained tail fraction (p. 210). He thereby lost the benefit of one of the most diagnostic fractions of the size frequency distribution curve.

For distinguishing river and beach sands the writer noted (1961, p. 517) that only medium to fine and very fine grained sands can be employed for relating moment measures to depositional environment. Coarser grained river sands ' can be either positively or negatively skewed and no predictable relationship could be determined' (FRIEDMAN, 1961, p. 517). The reason why coarse-grained sands are less useful in relating moment measures to an environment is that they are commonly bi- and polymodal which reflect a combination of modes of transportation of the detrital particles. The moment measures which describe such distributions are, as indicated in the previous studies referred to (1961, p. 517), quite unpredictable. On page 517 (FRIEDMAN, 1961) it was specifically stated that river sand samples with more than 5% of the grains in excess of 0.500 mm ($+1.00\,\Phi$) could not be employed for environmental distinction. Analysis of many sands led to this conclusion. Examination of GEES' fig. 4 showed that of his river sands 21% have mean values in excess of 0.500 mm. He does not give the values for the 5th percentile but they can be estimated from the mean and sorting of fig. 4. This estimate shows that in excess of 60% of GEES' samples are not acceptable for the type of study which he envisions. The 1961 study clearly was not designed for coarse-grained river sands from an alpine belt; it was designed for low relief coastal plains.

Despite GEES' choice in the selection of his samples, his discard of the diagnostic fine-grained fraction, and a sampling technique which does not employ the special precautions recommended in the 1961 paper, his study is an interesting contribution. If anyone is given the choice to guess the environment of one of two sands, each from a different environment, he could get the answer 50% correct by simply tossing a coin. The purpose of the scatter plots of the 1961 and 1962 studies was to improve these odds. No geologist should believe that one can come up with infallable environmental interpretations. In the 1961 study the terms '*commonly* can be distinguished', 'this *seems* to hold', '*generally* positively skewed', '*tend* to show' [italics were not part of the 1961 paper] were carefully used. GEES' plots improve the odds of environmental interpretation immensely. Despite his statement (p. 212) that ' no apparent separation (was) noted between beach and river sands', his fig. 3 shows distinct groupings of beach and river sands. His beach sands *tend to be* negatively skewed and well to moderately well sorted, whereas his river sands tend to be moderately well to moderately sorted. Because of the removal of the fine fraction, let alone the polymodality of his samples, nothing should be attempted to be said about the direction of the skew of his river samples. The writer and his students drew a line of separation on GEES' fig. 3 to see if this diagram cannot be improved; it showed that 24 of his total of 118 samples, or only about 20%, fell outside their environmentally designated fields. Only 4 river sands fell in the beach sand field and only 20 beach sands fell in the river sand field. In geology even under favorable conditions this is a remarkable improvement of the odds. GEES' fig. 2 cannot be improved on since here he used only one diagnostic parameter (skewness) and the data on his river sands, under the conditions of experiment, are not too meaningful.

GEES' fig. 4 is a scatter plot for distinguishing inland dune and river sands employing mean and standard deviation. A line of separation drawn by this writer shows that only 6 of 109, or 5%, of the sands fall outside their environmentally designated field. How can one expect more? GEES, in an attempt to completely separate environments, noted a separation of only 60.5% of the total number of samples (even that is an improvement over 50%), but his lines of separation were placed such that he had to discard 39.5% of the total number of samples for the sake of 5% that were exceptions.

In conclusion, the scatter plots discussed show groupings of sands in which a correlation exists between environment and statistical parameters, even though the sampling and analytical techniques differ from those of the writer's (1961, 1962) studies.

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